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An Agent-Based Model for the Role of Social Support in Mood Regulation

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Abstract. In this paper, a computational model of a human agent is presented which describes the effect of social support on mood. According to the literature, social support can either refer to the social resources that individuals perceive to be available or to the support that is actually provided in problematic situations. The proposed model distinguishes between both roles of social support. Simulation experiments are done to analyze the effect of the different types of support in different scenarios. It is shown that support can help to reduce the induced stress and thus can contribute to healthy mood regulation and prevention of depression. This presented model provides a basis for an intelligent support system for people with mood regulation problems that take the social network of people into account.

Keywords: Social support · Stress buffering · Human ambient agent

1 Introduction

Social support is one of the major factors that can help people in their life, especially during stressful events that may ultimately lead to depression. Social support plays a beneficial role in the mental wellbeing human beings through its impact on emotions, cognitions and behaviors [1], and through this even contributes to good physical health. Effective social support provided through adequate social networks can alleviate the effect of stress on an individual's psychological situation [2]. A person who is well integrated in social networks is less vulnerable to stress or depression.

Social support is often used in a broad sense, referring to any process through which social relationships might promote health and wellbeing. It is still a scientific questions by which mechanism the social support actually influences people's mental health. The psychological literature on social support and health includes multiple points of view, descriptions and effects. According to Gray et al. [3], subjective perception that support would be available if needed may reduce and prevent depression and unnecessary suffering. Literature [4, 5] differentiated structural and functional support measures. Structural supports refer to measures describing the existence and types of relationships (e.g. marital status, number of relationships). Functional support assesses whether interpersonal relationships serve particular functions (e.g. provide affection, feeling of belongings). According to Glanz et al. [6], social support is one of the important functions

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of the web of social relationship around an individual (its social network). People may provide social support either in the form of emotional or tangible support. In [7], it is explained that social support is associated with how networking helps people to cope with stressful events moreover it can enhance psychological wellbeing. Social isolation and low level of social support have been shown to be associated with medical illness (e.g. depression).

In this paper, we extend an existing model for mood regulation to describe the different types of effect of social support on mood regulation. The model involves different cognitive states of a human being that are considered as important for mood and appraisal of the situations. The model is used to investigate the difference in effect of perceived (expected) and received (actual) support [5, 7] from a social network during a period of stress.

This paper is structured as follows. In Sect. 2 contains a more detailed discussion of social support and its effect on mental health and wellbeing. The conceptual model of mood dynamics with extension of social support concepts are discussed in Sect. 3. In Sect. 4, a number of hypotheses about the effect of different types of support are formulated, which are then investigated by simulation experiments with the model. The results of the experiments and the consequences for the hypotheses are discussed in Sect. 5. Finally, Sect. 6 concludes the paper with a discussion about the usage of this model in agent-based support systems and an outlook to future work.

2 Background

The increasing interest of researchers in the concept of social support and its role in psychological and physical health opened several dimensions of research in the field of social, psychological and health sciences. Literature over the last decades demonstrated notable research in the field of social support and its effects on health and wellbeing [8]. Many studies have shown that stress is generated when an individual appraises a situation as stressful or threatening and does not have proper coping response [9, 10]. Moreover, if an individual appraises a stressful situation with a feeling of helplessness or hopelessness (e.g., without the perception or reception of support), the situation become more stressful to deal with [11].

Social support is a coping resource to handle stressful events. The protective mechanism of social support in the face of psychosocial stress is called a buffering mechanism. Social support may play a role at different points in the process of relating the occurrence of stressful events to illness [5, 7, 12]. Support may intervene between stressful events (or expectation of it) and a stress response by attenuating or preventing a stressful appraisal. The perception of support by others through a network will provide necessary resources and may redefine the potential for harm posed by a stressful situation and strengthen one's capability to cope with imposed stressful demands. Support may alleviate stress appraisal by providing a solution to the problem, by reducing the perceived importance of the problem. Thus social support prevents a particular situation from being appraised as highly stressful. Moreover, sufficient support may intervene between experience of stress and the beginning of the pathological outcome of illness by reducing the stress reaction or by directly influencing accompanying psychological and physiological

processes; so people are less reactive to perceived stress or by facilitating healthful behaviors [12].

According to literature [5, 7, 13] there are two hypothesis about the nature of the relationships between social support and health. First, the *main effect hypothesis* describes that social relationships have a beneficial effect regardless of whether individuals are under stress, as large social networks provide individuals regular positive experiences and socially rewarded roles in the community. This kind of support (i.e., a sense of identity, of purpose, and of meaning, belonging, and self-esteem) could be related to overall wellbeing because it provides positive effects during stressful events on self esteem, so integration in a social network may also help one to avoid negative experiences of life; otherwise that would increase the probability of psychological or physical disorder. Second, the *stress buffering hypothesis* describes that the social relationships are related to wellbeing only for individuals under stress. The buffering process takes into account both the variety of coping requirements that may be required by a stressful event and the range of resources that may (or may not) be provided by social relationships. Buffering effects occur when an individual perceives the availability of resources that will help him to respond to stressful events. Whereas it has been suggested that structural aspects of relationships might operate through the main effect model, functional aspects of relationships might operate through the stress buffering mechanism, and perceived availability of functional support is thought to buffer the effects of stress by enhancing individuals coping capabilities. The model proposed below simulates the stress buffering model as described in [8].

3 Model of a Human Agent

The human agent model (see Fig. 1) describes how the stress buffering affects different cognitive states and helps a person to deal with a bad event, and how this can increase

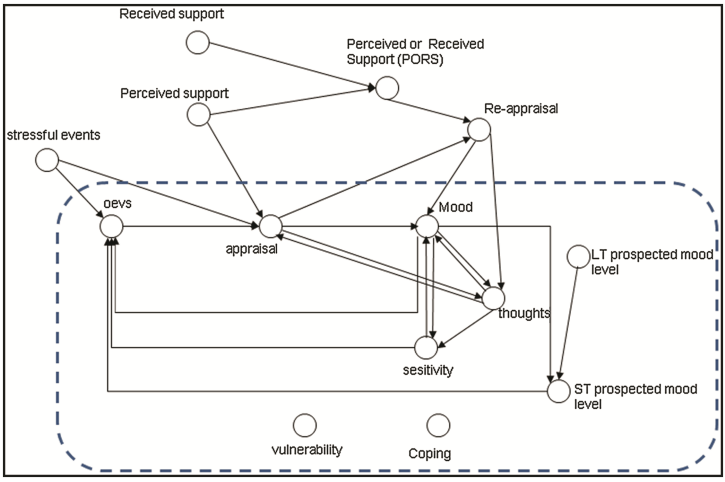

Fig. 1. Conceptual agent model of mood dynamics and social support

his/her coping skills. The model adopts an existing model for the dynamics of mood [14], and extends it by concepts of social support. In this section, the model of mood dynamics is described first, and then the extension parts are explained.

3.1 The Model of Mood Dynamics

The model of mood dynamics is depicted in the lower part of Fig. 1 (illustrated in the dashed box). The main concepts include the *mood level*, *appraisal* and *coping* skills of a person, and how the levels for these states affect the external behavior in the form of selection of situations over time (objective emotional value of situation). The model is based upon a number of psychological theories; see [14] for a mapping between the literature and the model itself. A short definition of each state and its role is explained in Table 1.

In the model a number of states are defined, whereby to each state at each point in time a number from the interval [0,1] is assigned. First, the state objective emotional value of situation (*oevs*) represents the value of the situation a human is in (without any influence of the current state of mind of the human). The state *appraisal* represents the current judgment of the situation given the current state of mind (e.g., when you are feeling down, a pleasant situation might no longer be considered pleasant). The *mood* level represents the current mood of the person, whereas *thoughts* indicates the current level of thoughts (i.e., the positivism of the thoughts). The *long term prospected mood* indicates what mood level the human is striving for in the long term, whereas the *short term prospected mood level* represents the goal for mood on the shorter term (in case you are feeling very bad, your short term goal will not be to feel excellent immediately, but to feel somewhat better). The *sensitivity* indicates the ability to select situations in order to bring the mood level closer to the short term prospected mood level. *Coping* expresses the ability of a human to deal with negative moods and situations, whereas *vulnerability* expresses how vulnerable the human is for negative events and how much impact that structurally has on the mood level. Both coping and vulnerability have an influence on all internal states except the prospected mood levels; but in Fig. 1 those arrows are left out for clarity reasons. Finally, the stressful world events state indicates an external situation which is imposed on the human (e.g. losing your job). Please see [14] for more details about this model.

3.2 Extending the Model with Social Support Aspects

Social factors can promote health through two generic mechanisms: stress-buffering and main effects [1, 5, 12]. As mentioned, in this paper the focus is on stress buffering; this mechanism is often considered by psychologists, especially by those interested in intervention. This model asserts that health benefits from social connections by providing psychological and material resources needed to cope with stress. In the literature, an important difference is made between actual and perceived support; they are included as two separate states in the agent model introduced here.

Table 1. Definition of states of conceptual model

Short name	Definition
Stressful event	Circumstances in the world that affect the situation in a stressful manner (e.g. losing his job)
OEVS	The objective emotional value of situation (OEVS) represents how an average person would perceive the situation
Appraisal	The current judgment of the situation given the current state of mind (e.g., when you are feeling down, a pleasant situation might no longer be considered pleasant)
Mood	The complex notion of mood is represented by the simplified concept *mood level*, ranging from low corresponding to a bad mood to high corresponding to a good mood
Thoughts	The mood level influences and is influenced by *thoughts*. Positive thinking has a positive effect on the mood and vice versa
Sensitivity	This node represents the ability to change or choose situations in order to bring mood level closer to prospected mood level. A high sensitivity means that someone's behavior is very much affected by thoughts and mood, while a low sensitivity means that someone is very unresponsive
St-prospected mood level	The mood level someone strives for, whether conscious or unconscious is represented by *prospected mood level*. This notion is split into a *long term (LT) prospected mood level*, an evolutionary drive to be in a good mood, and a *short term (ST) prospected mood level*, representing a temporary prospect when mood level is far from the prospected mood level
Lt-prospected mood level	
Vulnerability	Having a predisposition for developing a disorder
Coping	*Coping* is used in the model presented in this deliverable by means of continuously trying to adapt the situation in such a way that an improvement is achieved
Received support	The actual support which person received from his social network
Perceived support	The perception that others will provide appropriate aid if it is needed. The belief that others will provide necessary resources may bolster one's perceived ability to cope with demands, thus changing the appraisal of the situation and lowering its effective stress [9]
Perceived or received support	Whole amount of social support (both received and perceived received)
Re-appraisal	Reappraisal process occurs when a person, reappraises the stress experience in the presence of actual support as well as perceived support

Actual Support: This state presents the value of actual support which person received from his social network (e.g., your friend provides some money when you temporary loss your job).

Perceived Support: According to the psychological literature, the critical factor in social support operating as a stress buffer is the perception that others (even one reliable

source) will provide appropriate aid [1, 5, 15]. A belief that (s)he can ask a friend for help changes the person's opinion about the situation. According to [16], the perceived availability of social support in the face of a stressful event may lead to a more benign appraisal of the situation, thereby preventing a cascade of ensuing negative emotional and behavioral responses. As a result, the value of this state has effect on *appraisal* in the proposed model.

In addition to these two kinds of support states, some additional states are added to the previous mood model.

Perceived or Received Support: The value of this state shows the whole amount of social support (both perceived and actually received). According to the psychological literature, the belief that others will provide necessary resources may bolster one's perceived ability to cope with demands [5, 17, 18]. For instance, the perceived availability of functional support is thought to buffer the effects of stress by enhancing an individual's coping abilities [16]. So, this state has effect on the coping skills of person. Please note that the value of this state has influence on the state *coping*; however this is not shown as an arrow in Fig. 1.

Re-appraisal: The *reappraisal* state uses the concept of the perception of the support in addition to the appraisal state. More specifically, the reappraisal state uses the concept perception as well as actual reception of the support; a reappraisal process occurs when a person reappraises the stress experience (generated by the appraisal) in the presence of actual support as well as perceived support. Reappraisal intervenes between the actual and perceived support and stress and the pathological illness.

3.3 Numerical Details of the Agent Model

As mentioned, for the model of mood dynamics (the lower part of Fig. 1, illustrated in the dashed box) an existing model was adopted. In the simulations, the settings of this model were also adopted. Due to the lack of space, we have to refer to original article [14] for the numerical details of this part of model. In the simulations weights of arrows which connect the new states to each other or to old states have been set at the following values: $w_{perceived,appraisal}$ 0.2, $w_{perceived,appraisal}$ 0.2, $w_{perceived,PORS}$ 1, $w_{received,PORS}$ 1. The weights of all arrows to the *reappraisal* are the same as arrows to/from *appraisal*, except $w_{PORS,Reappraisal}$ which is 0.2. Moreover, in this new model the *mood* states thoughts and *sensitivity* are affected by an average value of *appraisal* and *reappraisal* instead of only *appraisal*. Furthermore, the initial for the simulation, are as follows: *coping* 0.1, *vulnerability* 0.9, *LT_prospected* 0.6, *ST_prospected* 0.6, *oevs* 0.6, *appraisal* 0.8, and *sensitivity* 0.6.

In each iteration, the value of each state (except *coping*), V_{new}, is defined according the weighted sum of its inputs from other, connected states and its old value (V_{old}):

$$V_{new} = V_{old} + af * (w_1 V_1 + W_2 V_2 + ..)$$

The adaptation factor *af* for all states in the mood model is 0.1. The new value of coping is calculated by this formula ($af_{coping} = 0.0005$):

$$\text{Coping}_{\text{new}} = \text{coping}_{\text{old}} + af_{coping} * \text{coping}_{\text{old}} * (0.55 - \text{coping}_{\text{old}}) * \text{PORS}$$

4 Simulation Experiments

The human agent model presented above is used to make a comparison between what the model predicts for the human agent, and what actually holds in the real world (according to the literature).

4.1 Hypotheses

The objective of this paper is proposing a cognitive model that is consistent with related theories about social support. A number of expected behaviors of the model can be formulated:

H1. Social support (both perceived and actual) leads to less negative mood.
H2. A person who has a suitable social support will be more robust against bad events.
H3. Perception that others will provide appropriate aids during bad events (perceived support) is more helpful than the actual support itself.
H4. Social support can help people to learn how to cope with bad events. It means that at the very first times which a bad event happen, (s)he needs social support to cope with. But, after some successful experiences to handle the problem, (s)he will be more robust to cope with events with almost same demands.

4.2 Assumptions Behind the Example Simulations

To do the simulation experiments, some simplifying assumptions about the availability of *actual* and *perceived supports* and their affect on the *coping* have been made:

- Perception about the availability of support starts meanwhile the stressful event and fades out gradually after the event.
- In cases that actual support occurs, it starts meanwhile the event, and fades out gradually (10 times faster than perceived support) after the event.
- Both kinds of social support have a positive effect on coping.

4.3 Simulations

In the **first experiment**, a scenario is simulated which one bad event (stressful_event with value 0.2) occurs for the person and lasts for 3 days. Figure 2 shows the changes in mood and appraisal for four different conditions:

(a) No perceived support, no actual support
(b) No perceived support, just actual support
(c) Just perceived support, no actual support
(d) Both perceived and received support

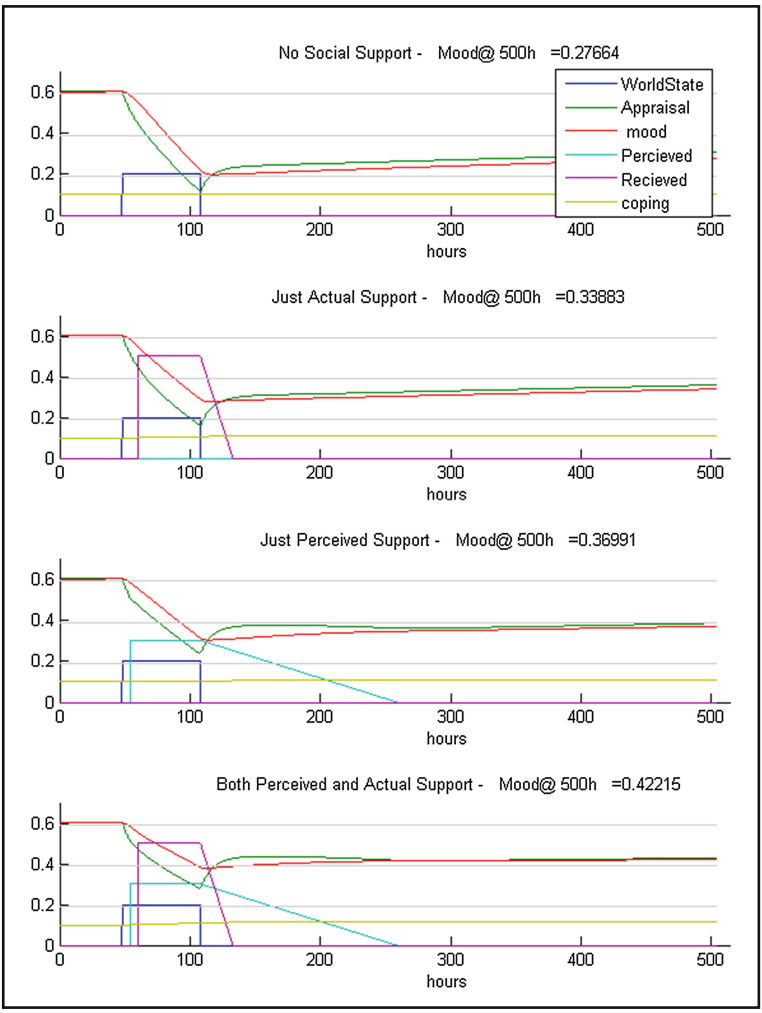

Fig. 2. Simulation results of the first experiment. Studying the influence of perceived and actual support on handling a bad event. Value of mood after 500 h is mentioned above each graph. The value of each state is a value between [0,1]

As it can be seen, the value of mood and appraisal decrease much when there is not any kind of support (a). In contrast, only a minimal decrease in the value of mood happens when both perceived and received are available (d). Moreover, comparison

between situations in which just one kind of support is available shows that the perception of support has a more positive effect on mood than actual support.

In the **second experiment**, we consider three different scenarios. In the first scenario the person experiences a very stressful event (value 0.2). In the next scenarios, two and four events happen, but the events are less negative (value of 0.3 and 0.1 respectively). In all scenarios, the bad event lasts for 2.5 days.

The scenarios are simulated for three types of persons with different personalities. For each of the persons, we consider 5 different combinations of perceived and actual support: no support, a (little) perceived support, a (little) actual support. Together this results in $3 \times 3 \times 5$ is 45 simulations.

The following types of persons are used first, an emotionally stable person, defined by having good coping skills that balance out any vulnerability, and by having the desire to have a good mood: coping value is 0.5, vulnerability 0.5 and LT prospected mood level 0.8. An emotionally slightly unstable person is defined by having some vulnerability and bad coping skills and the desire to have a medium mood: settings 0.9, 0.1 and 0.6 respectively. The third type, an emotionally very unstable person, is characterized by settings 0.01, 0.99 and 0.6. For type 1 the OEVS is 0.8, for type 2 it is 0.94 and for type 3 the stable OEVS is 0.999.[1] The results of the 45 simulations are presented in Table 2 and Fig. 3, the figure depicts the maximum value of mood during simulation given different increasing values for support. The idea behind this is that the maximum value of the mood is an indicator for the recovery of a person from a depression.

According to some literature, depression is defined as a mood level below a threshold (usually 0.5) during at least 336 h (two weeks). Table 2 shows the length of period that the mood is bellow two particular thresholds (0.5 and 0.25), the cases that the length is higher than 336 h are highlighted, and the average of value of mood in the first two weeks of depression is mentioned in the second line of cell. Lower values of mood refer to a stronger depression, which is shown by darker colors. The table illustrates that social support in some cases prevents the depression; and in some other cases it decrease the depth.

As in can be seen in Fig. 3 the social support is beneficial mostly for a person number 2, but not for a very stable or very unstable person. A very stable person seems not to need to social support; on the contrary, social support cannot help a very unstable person. The exception is for a very unstable person: when some moderate events happen for this person, a high value of perceived social support can help to recovery after the event.

On the other hand, by focusing on the graphs related to person 2, we can see that the graph of perceived social support has a higher gradient. This suggests that the same amount of perceived social support is more effective than actual support.

In **the third experiment**, the long-term effect of social support is studied. Handling a bad event by help of social support may lead to bolster one's perceived ability to cope with demands, and the person will be more ready to deal with next events (with almost the same kinds of demands). In this simulation, several bad events occur with interval of one month. Each bad event lasts for 2.5 days; during each event, the value of

[1] The start value for OEVS needs to be calculated for each type so that when no events occur, the person stays balanced with al variables equal to LT prospected mood level.

Table 2. Length and depth of period which mood is less than threshold (in hours). First number: the length of period when mood is bellow threshold; second number: average mood value during this period. Situations in which length >336 h are highlighted.

Personality	Perceived or Actual Support	Threshold = 0.5			Threshold = 0.25		
		Scenario 1	Scenario 2	Scenario 3	Scenario 1	Scenario 2	Scenario 3
Stable Person	P=0,A=0	119 0.322	93 0.407	0 -	37 0.196	0 -	0 -
	P=0.25,A=0	103 0.331	57 0.445	0 -	29 0.205	0 -	0 -
	P=0.5,A=0	86 0.341	17 0.484	0 -	19 0.220	0 -	0 -
	P=0,A=0.25	117 0.327	83 0.422	0 -	34 0.2	0 -	0 -
	P=0,A=0.5	113 0.334	69 0.439	0 -	30 0.206	0 -	0 -
Slightly Unstable Person	P=0,A=0	1286 0.075	1281 0.065	1261 0.233	1273 0.064	1257 0.043	1139 0.116
	P=0.25,A=0	1286 0.091	1280 0.090	1241 0.363	1273 0.081	1252 0.066	50 0.241
	P=0.5,A=0	1286 0.126	1279 0.14	1056 0.456	1013 0.117	849 0.118	0 -
	P=0,A=0.25	1286 0.078	1281 0.072	1256 0.287	1273 0.067	1255 0.049	675 0.167
	P=0,A=0.5	1286 0.083	1281 0.085	1245 0.342	1273 0.072	1253 0.060	174 0.234
Unstable Person	P=0,A=0	1287 0.035	1282 0.039	1265 0.131	1275 0.022	1261 0.015	1172 0.032
	P=0.25,A=0	1287 0.041	1281 0.048	1249 0.246	1274 0.028	1257 0.021	1077 0.064
	P=0.5,A=0	1287 0.047	1280 0.063	1147 0.346	1274 0.033	1251 0.032	756 0.136
	P=0,A=0.25	1287 0.038	1282 0.042	1261 0.162	1275 0.025	1260 0.017	1158 0.046
	P=0,A=0.5	1287 0.039	1282 0.046	1254 0.212	1275 0.026	1258 0.02	1132 0.075

stressful_event is 0.2. It is assumed that both perceived and received social supports are available during all events.

Figure 3 shows the result of this simulation experiment. As it can be seen, the value of coping skills is increasing during each event. As a result, the last events have less effect on mood and appraisal, in comparison to the first ones. In fact, during the first event, the value of mood is decreased by 0.235; while it is decreased only by 0.164 during the last event.

5 Discussion

The results of the experiments described previous section are used to validate the hypotheses about our model about the relation between support and mood. Based on the literature, four different hypotheses have been defined.

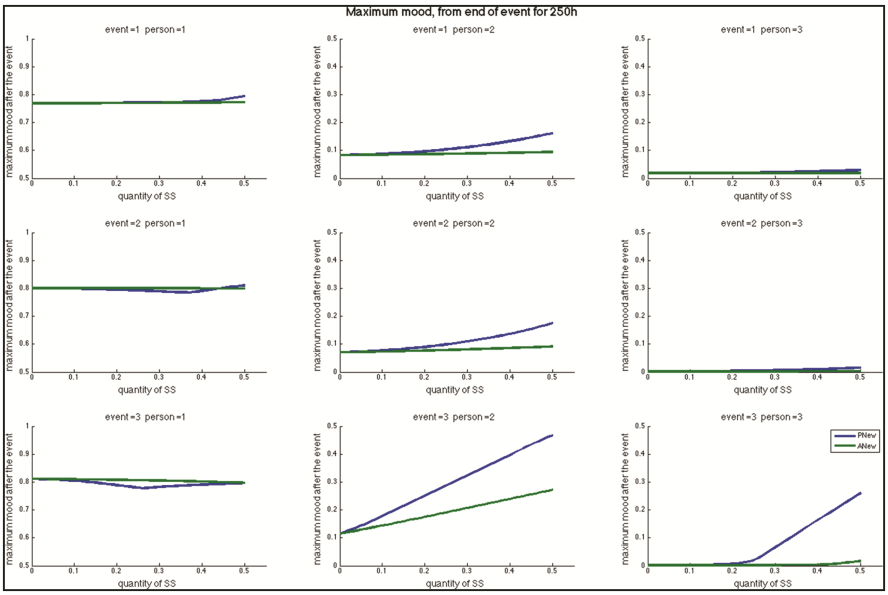

Fig. 3. The maximum value of mood for different amount of social support (perceived and actual)

H1. The first hypothesis states that social support (both perceived and actual) leads to less negative mood. The simulations in Fig. 2 show that mood goes down when a stressful event occurs. However, when a person has a perception of adequate social support he appraises the situation less negative and the lowest value of the mood is less negative. Actual support doesn't have much effect on the appraisal, but still reduces the effect of the stressful event. Thus, both types of supports leads to less depression in our model and H1 is validated

H2. The second hypothesis states that a person who has a suitable social support, will be more robust against bad events. Figure 3 shows that this only holds for a moderately stable person (there we see that the mood value increases with additional support), but not for very stable or very unstable persons (except for scenario 3). A similar patterns is visible in Table 2. The hypothesis partly holds

H3. The third hypothesis says that perceived support is more helpful than actual support. Figure 3 indeed shows that – when there is a positive effect – the perceived support is more helpful than the actual support (in the figure the blue line is above the green line). Thus, this hypothesis holds

H4. The fourth hypothesis states that social support can help people to learn how to cope with bad events. Indeed Fig. 4 clearly shows that the coping skills increase after negative events. As a result, the last events have less effect on mood and appraisal, in comparison to the first ones.

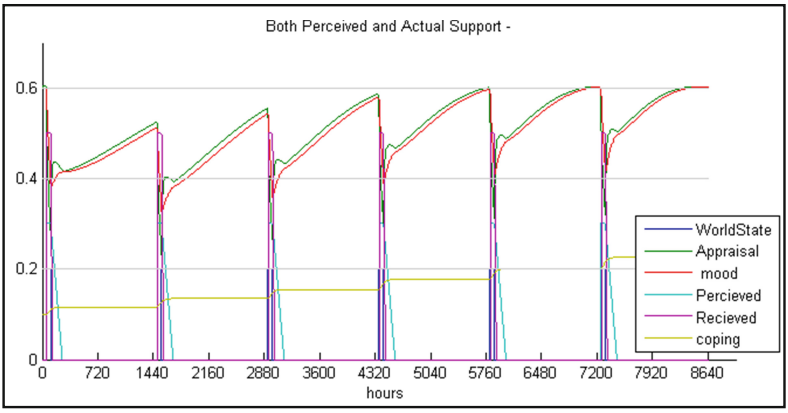

Fig. 4. Increasing the coping skills after during each bad event. The value of each state has a value between [0,1].

In summary, social support has a positive effect on mood and can prevent the subject from low mood, social support also has positive impact on coping skills and it enable a person to learn how to cope during stressful events, but this mainly holds for moderately stable persons.

6 Conclusion and Future Work

The computational model presented in this paper is the part of ongoing work on social support and its effects on health and psychological wellbeing, particularly on stress and depression. In this paper an extension of a human agent model of mood dynamics is presented that takes social support into account. It distinguishes between actual support and perceived support. The simulation experiments show that the effect of different types of support are in line with the literature.

This model can form the basis of a support system that provides advices for persons based on a prediction of the effect of situations on a person's mood. For such a system, it is important to be able to be able to estimate whether a person has social support and how large that is. For this, it might be possible to use data from social media. In the current decade, many electronic social environments have been developed in the form of social media or social network sites (e.g., Facebook, Twitter, Myspace). These social media provide a social environment where people can communicate with each other through forming their own social networks or groups, and thus integrating with these social networks. Such social media environments can be used for data collection (e.g., network size, frequency of the contacts, locations, etc.) to develop, analyze, and validate predictive models.

In future work, it is planned to investigate the relationships between measureable aspects of social environment (e.g. size and structure of a social network), and the factors used in the current model about the influence of social support on the cognitive states of a human. This could lead to a support system that is able to exploit social network data for

predicting the mood of a person. Moreover, the effects of different kinds of intervention on persons and social networks can be analyzed and evaluated through empirical data.

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